ENERGY ENGINEERING ANALYSIS PROGRAM

REDSTONE ARSENAL, ALABAMA

ENERGY SURVEY OF FOX ARMY COMMUNITY HOSPITAL

FINAL REPORT

MARCH, 1987

EXECUTIVE SUMMARY

Prepared for

MOBILE DISTRICT, CORPS OF ENGINEERS

P.O. BOX 2288

MOBILE, ALABAMA

By

BENATECH, INC.

Engineering & Energy Consultants

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ARMY CONTRACT NO. DACA01-85-C-0131,

PART III

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
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INDEX OF VOLUMES

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EXECUTIVE SUMMARY

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1. INTRODUCTION

1.1 BACKGROUND

This is the executive summary of an Energy Engineering Analysis Program (EEAP) Study that was conducted at the Fox Army Community Hospital, Redstone Arsenal, Alabama by the firm of BENATECH, INC. Work was begun on the hospital energy audit during November, 1985 under Contract No. DACA01-85-C-0131. A total of 88 energy conservation opportunities (ECOs) were investigated, resulting in 7 projects being recommended.

A three volume report has been prepared that describes in detail the work accomplished during the study. Volume I, Part 1 of 2, provides all the descriptive Narrative for the report. Volume I, Part 2 of 2, contains a copy of the Scope of Work and the Program Documentation. Volume II contains ECO calculations and backup technical details. Volume III contains computer simulation printouts.

This executive summary follows the narrative outline with minor modifications and summaries in the form of charts and graphs for easier interpretation.

1.2 SCOPE OF WORK

The Scope of Work (copy included in Appendix A, Volume I) for the hospital study required the performance of a comprehensive energy audit and analysis for the purpose of identifying energy conservation opportunities (ECOs) which can be implemented. The Contract Scope of Work (SOW) for the Redstone Arsenal's Fox Army Hospital study outlines the following specific requirements:

- Perform a complete Energy Audit and Analysis of the entire hospital facility.
- Identify all practical Energy Conservation Opportunities (ECOs) including low/no cost items.
- Prepare programming documentation for all Energy Conservation Investment Program projects.
- Prepare implementation documentation for all justifiable energy conservation opportunities.
- List and prioritize all recommended energy conservation projects.

- Prepare a comprehensive report which will document the work accomplished, the results, and the recommendations.

Each item of the Contract Scope of Work has been addressed during the development of the study. The results of accomplishments are presented in the narrative report and reference volumes as required.

2. PRESENT ENERGY CONSUMPTION

2.1 TOTAL ANNUAL ENERGY USED

In order to determine actual energy usage by Fox Army Hospital, electrical and fuel oil records are necessary. Existing electric and oil consumption records provide insight into the utility rates being charged as well as the patterns of energy consumption. Electrical bills for Redstone Arsenal were obtained from the Facility's Engineer so that an energy charge per KWH could be calculated. Separate electrical meters were installed at the hospital in December 1984; however, records were available for just under one year. Electrical metering at Fox Army Hospital began in Mid-December (1984), and records cease in October (1985).

Fuel oil consumption is not metered. Fuel logs obtained from the Facitity Engineers show fuel deliveries, but not actual consumption. Delivery frequency and varying consumption rates provide sufficient information for estimates to be made, however actual consumption is not available.

There was sufficient data to establish the utility costs for all fuels used at the hospital. Table ES.1 describes the utility rates used throughout the analysis and the energy simulations. The electric utility rate used reflects the electric rate change, Contract Modification DACA01-85-C-0131-P00003, signed 10/Mar/87.

Another way of establishing energy usage for Fox Army Hospital was running a building energy analysis program. The program utilized by BENATECH was developed by Elite Software Development (ESD). This energy simulation program uses ASHRAE methods and standards for calculating energy usage of a building.

2.2 VALIDITY OF COMPUTER SIMULATION

Computer simulation of building energy usage has been available over ten years, with considerable advancement in the past five years. The user has the ability to estimate building energy consumption by mathematically modeling the building construction, occupancy, equipment, and systems through the use of a computer. Simulation programs range from relatively simple programs that can be

inputted and run on a microcomputer to sophisticated programs that require a mainframe computer.

It is important to understand the limitations of computer simulation programs in order to properly interpret the output. The handicaps described below, do not prohibit the analysis from being performed using ESD, it merely requires a more complex techniques to be used to simulate as much of the buildings useage as possible. ESD allows for only one type of chiller. Also, ESD is limited in allowing only one thermostat setting for the entire building. Plus, the hospital has some air handlers that run 24 hours/day, some that run 9 hrs/day and one that is shut off completely on weekends. Each air handler must be identified with a zone. Air Handling Unit No. 4 supplies air to both the first and second floor areas and is broken into two zones for convenience. To take these requirements into account, ESD is run under six categories with the various results combined to give the overall building assessment. These six ESD zones are outlined in Section 2 of the Narrative and Volume III - Computer Simulations. Even with the above limitations, computer simulation does provide a reasonable benchmark of the current energy consumption, when utility data is unavailable or unreliable. Table ES.2 is the Baseline utility ledger, showing the month to month utility costs for the hospital. Utility consumption shown in Table ES.2 is a composite calculation of the Baseline simulation and spreadsheet calculations. The spreadsheet calculations use the hour by hour cooling load calculations to estimate the boiler input energy required when the absorption chiller operates. For a complete explaination of the methodolgy used to estimate the benchmark/current energy consumption see Volume III - Computer Simulations.

A Baseline energy simulation of the present conditions at the hospital was run. The simulated energy usage in BTUs per conditioned square foot (109,500 sq.ft.) is 328,000 BTU/sq.ft. (site)/ 647,000 BTU/sq.ft. (source). Based on the utility rates described earlier, the resulting energy costs are approximately $2.60 $/sq.ft.

A Proposed energy simulation was run with seven projects and one operating and maintenace recommendation implemented as described in Section 7 of the Narrative and in Volume III - Computer Simulations. Interdependencies between ECOs were considered in the second energy simulation run. The second simulation energy usage is estimated to be 205,000 BTU/sq.ft (site)/ 526,200 BTU/sq.ft. (source). The energy costs drop to $2.03 $/sq.ft. Table ES.3 shows the

proposed energy consumption on a month by month basis. Upon implementation of all projects and recommendations, there will be a 37% decrease in energy consumption (MBTU) corresponding to a 22% decrease in operating cost.

To more completely describe the simulated energy savings on a month to month basis Graph ES.1 was prepared. Graph ES.1 compares the Baseline and Proposed energy consumption, showing the energy and cost savings to be uniform throughout the year. Graph ES.2 shows which fuels are being saved. Graphs ES.3 and ES.4 shows on a BTU/sq.ft. basis energy consumption by end use for the Baseline and Proposed simulation.

3. ENERGY CONSERVATION ANALYSIS

3.1 INTRODUCTION

The Scope of Work contains a comprehensive list of activities to be completed by BENATECH. These activities included a detailed energy audit of the hospital facility. These site surveys and investigations were planned and completed based upon the recommended ECO lists in conjunction with BENATECH's prepared energy checklists and survey data. The process of evaluation was as follows:

- Formulate a survey plan and gather field data.
- Investigate the ECOs and analyze field data.
- Evaluate potential ECOs and prepare energy report.
- Prepare documentation and develop project information.

3.2 INVESTIGATION OF ECOs

The investigation of ECOs began after completion of the field survey visits and the resulting data reduction. There was a primary week-long visit and then several other 3-5 day field survey trips. The initial investigation examined the potential of the ECO's listed in table ES.4 from the Scope of Work. After the bulk of the field surveys were completed and ECO analysis was nearing completion many of the ECO's contained in ES.4 were found to be inappropriate or did not pay back/funding requirments. Table ES.5 shows the ECOs which were recommended for implementation. For a more complete description of the disposition of individual ECOs see Volume I, Section 4. Table ES.7 shows ECO's which are not applicable or else have already been implemented.

3.3 EVALUATION OF POTENTIAL SAVING ECOs

Once the ECOs which met the appropriate savings/funding requirements were isolated, the "As-Proposed" simulation was developed. The ECOs were grouped into funding packages based on equipment category. Table ES.6 shows the 7 projects and operation and maintenance (O&M) recommendation resulting from this study. Centrifugal Chiller Installation is listed as an O&M recommendation because the savings resulting from implementing the ECO, can be otained using the existing centifugal chiller.

3.4 PROJECTS DEVELOPED

3.4.1 ECIP Projects

Based on the EEAP energy study, there were no ECIP projects identifed for Fox Army Community Hospital.

3.4.2 Non-ECIP Projects

The remaining projects identified have a total investment cost of $361,115. The following list is a summary of the projects developed. Complete project documentation is included in Volume I, Part 2 of 2, Appendix B. Page numbers corresponding the project are shown below.

QRIP Projects	Page
No QRIP projects were identified.	
PECIP Projects	
Boiler Optimization	3
Lighting	39
Work Orders	
1) Supply Make-up Air to Kitchen Exhaust Hood	92
2) Optimizing Air Distribution Systems	106
3) Energy Efficient Motors	126
4) Domestic Hot Water Energy Reduction	184
5) Unoccupied Zone Shutdown	230

Operation and Maintenance

1) Clean cooling and heating coils on AHUs.
2) Maintain filters of AHUs.
3) Revise lighting cleaning schedule.
4) Repair and maintain water and steam insulation.
5) Shut off range hood exhaust.
6) Check motor belt condition.

3.5 OTHER RECOMMENDATIONS

In addition to the above-mentioned projects, certain recommendations resulted from the field surveys. These recommendations listed below are reviewed further in Section 8 of this report.

1) Seal leaking air distribution system ductwork.
2) Performance-test cooling towers which appear to be undersized.

3.6 ENERGY MONITORING AND CONTROL SYSTEM

In accordance with the Scope of Work, an Energy Monitoring and Control System (EMCS) was evaluated for the hospital. The savings-to-investment ratio (SIR) for the EMCS was found to be 0.97, which makes it inelligible for project programming. Refer to Volume I, Narrative, Part 1 of 2, Section 5, for details of the EMCS analysis.

TABLE ES.1

UTILITY RATES FOR REDSTONE ARSENAL

ELECTRICAL RATE

The average electrical cost is determined from a record of utility bills for Redstone Arsenal. The electrical utility data and rate structure were provided by the Tennessee Valley Authority (TVA).

Average Electrical Cost = $0.04313 / KWH

Using 11,600 BTU/ KWH,
$0.04313 / KWH x 1 KWH/ 11,600 BTU x 1.0xE6 BTU/ 1 MBTU= $3.718 / MBTU

For projects whose sole purpose is to reduce demand charges, the following electrical charges will be used (from General Power Rate-Schedule GP-1):

Electrical Energy Cost = $0.02703 / KWH

Electrical Demand Charge = $7.56 / KW

FUEL OIL RATES

Current fuel oil costs were provided by the Facility Engineer. The costs are as follows:

Fuel Oil 5 Cost = $0.68 / gallon

Heating Value = 147,000 BTU/ gallon
(from ASHRAE Fundamentals Handbook 1985)

$0.68 / gal x 1 gal/ 147,000 BTU x 1,000,000/ 1 MBTU = $4.626 / MBTU

Fuel Oil 2 Cost = $0.82 / gallon

Heating Value = 138,700 BTU/ gallon
(from information from Corps of Engineers)

$0.82 / gal x 1 gal/ 138,700 BTU x 1,000,000/ 1 MBTU = $5.912 / MBTU

BASELINE UTILITY LEDGER

REDSTONE ARSENAL

MONTH	HEATING DEG-DAYS base 65F	COOLING DEG-DAYS base 65F	ELECTRICITY KWH	ELECTRICITY KBTU	ELECTRICITY COST TOTAL	ELECTRICITY COST PER KWH	FUEL - #5 FUEL OIL GAL	FUEL - #5 FUEL OIL KBTU	FUEL - #5 FUEL OIL COST TOTAL	FUEL - #5 FUEL OIL COST PER GAL	FUEL - DIESEL GAL	FUEL - DIESEL KBTU	FUEL - DIESEL COST TOTAL	FUEL - DIESEL COST PER GAL	TOTAL $	TOTAL ENERGY KBTU
JAN	916	0	226,593	773361	$9,772	$0.0431	19556	2874661	$13,298	$0.680	91	12621	$75	$0.820	$23,145	3660643
FEB	569	0	235,922	805202	$10,175	$0.0431	14216	2089824	$9,667	$0.680	91	12621	$75	$0.820	$19,917	2907647
MARCH	479	3	283,939	969085	$12,246	$0.0431	12176	1789815	$8,279	$0.680	91	12621	$75	$0.820	$20,600	2771521
APRIL	225	23	364,587	1244335	$15,724	$0.0431	8761	1287906	$5,958	$0.680	91	12621	$75	$0.820	$21,756	2544862
MAY	70	120	404,076	1379110	$17,427	$0.0431	10597	1557819	$7,206	$0.680	1472	204166	$1,207	$0.820	$25,840	3141095
JUNE	2	357	449,195	1533103	$19,373	$0.0431	9102	1338047	$6,190	$0.680	1500	208050	$1,230	$0.820	$26,792	3079200
JULY	0	383	494,112	1686403	$21,310	$0.0431	7742	1138104	$5,265	$0.680	1800	249661	$1,476	$0.820	$28,051	3074168
AUG	0	352	497,397	1697616	$21,452	$0.0431	6921	1017366	$4,706	$0.680	1800	249661	$1,476	$0.820	$27,634	2964643
SEPT	26	182	431,295	1472009	$18,601	$0.0431	9232	1357068	$6,278	$0.680	91	12621	$75	$0.820	$24,953	2841698
OCT	32	140	341,982	1167185	$14,749	$0.0431	10568	1553510	$7,186	$0.680	91	12621	$75	$0.820	$22,010	2733316
NOV	499	1	278,489	950484	$12,011	$0.0431	13307	1956105	$9,049	$0.680	91	12621	$75	$0.820	$21,134	2919210
DEC	407	2	258,701	882946	$11,157	$0.0431	16213	2383384	$11,025	$0.680	91	12621	$75	$0.820	$22,257	3278951
TOTAL	3,225	1,563	4,266,287	14,560,839	$183,996	$0.0431	138,392	20,343,608	$94,106	$0.680	7,300	1,012,506	$5,986	$0.820	$284,089	35,916,953

CONDITIONED BUILDING AREA 109,500 square feet

GENERAL NOTES

ALL FIGURES SHOWN ARE SITE VALUES.

ENERGY UTILIZATION INDEX

EUI = TOTAL ENERGY CONSUMPTION in BTU/YR/ CONDITIONED GROSS AREA in SQ. FT.

= 35,916,953 KBTU/YR / 109,500 SQ. FT.

= 328 KBTU/(SQ. FT.*YR) = 328,009 BTU/(SQ. FT.*YR)

TABLE ES.2

COST UTILIZATION INDEX

CUI = TOTAL ENERGY COST in $/YR/ CONDITIONED GROSS AREA in SQ. FT.

= $284,089 $/YR / 109,500 SQ. FT.

= $2.594 $/(SQ. FT.*YR)

PROPOSED UTILITY LEDGER REDSTONE ARSENAL

MONTH	HEATING DEG-DAYS base 65F	COOLING DEG-DAYS base 65F	ELECTRICITY KWH	ELECTRICITY KBTU	ELECTRICITY COST TOTAL	ELECTRICITY COST PER KWH	FUEL - #5 FUEL OIL GAL	FUEL - #5 FUEL OIL KBTU	FUEL - #5 FUEL OIL COST TOTAL	FUEL - #5 FUEL OIL COST PER GAL	FUEL - DIESEL GAL	FUEL - DIESEL KBTU	FUEL - DIESEL COST TOTAL	FUEL - DIESEL COST PER GAL	TOTAL $	TOTAL ENERGY KBTU
JAN	916	0	184,487	629655	$7,957	$0.0431	14404	2117318	$9,794	$0.680	91	12621	$75	$0.820	$17,826	2759594
FEB	569	0	220,578	752834	$9,513	$0.0431	7721	1134944	$5,250	$0.680	91	12621	$75	$0.820	$14,838	1900399
MARCH	479	3	289,790	989053	$12,498	$0.0431	4643	682519	$3,157	$0.680	91	12621	$75	$0.820	$15,730	1684193
APRIL	225	23	387,866	1323785	$16,728	$0.0431	6	899	$4	$0.680	91	12621	$75	$0.820	$16,807	1337305
MAY	70	120	436,798	1490792	$18,838	$0.0431	24	3579	$17	$0.680	1472	204166	$1,207	$0.820	$20,062	1698537
JUNE	2	357	462,125	1577232	$19,931	$0.0431	665	97754	$452	$0.680	1500	208050	$1,230	$0.820	$21,613	1883036
JULY	0	383	491,771	1678413	$21,209	$0.0431	1473	216559	$1,002	$0.680	1800	249661	$1,476	$0.820	$23,687	2144633
AUG	0	352	490,304	1673407	$21,146	$0.0431	1354	198971	$920	$0.680	1800	249661	$1,476	$0.820	$23,542	2122039
SEPT	26	182	451,065	1539485	$19,454	$0.0431	336	49394	$228	$0.680	91	12621	$75	$0.820	$19,757	1601500
OCT	32	140	361,759	1234685	$15,602	$0.0431	1078	158405	$733	$0.680	91	12621	$75	$0.820	$16,409	1405711
NOV	499	1	281,408	960446	$12,137	$0.0431	5122	752875	$3,483	$0.680	91	12621	$75	$0.820	$15,694	1725942
DEC	407	2	239,192	816361	$10,316	$0.0431	9181	1349561	$6,243	$0.680	91	12621	$75	$0.820	$16,633	2178543
TOTAL	3,225	1,563	4,297,143	14,666,148	$185,327	$0.0431	46,005	6,762,778	$31,284	$0.680	7,300	1,012,506	$5,986	$0.820	$222,597	22,441,432

CONDITIONED BUILDING AREA 109,500 square feet

GENERAL NOTES
ALL FIGURES SHOWN ARE SITE VALUES.

ENERGY UTILIZATION INDEX

EUI = TOTAL ENERGY CONSUMPTION in BTU/YR/ CONDITIONED GROSS AREA in SQ. FT.

= 22,441,432 KBTU/YR / 109,500 SQ. FT.

= 205 KBTU/(SQ. FT.*YR) = 204,945 BTU/(SQ. FT.*YR)

TABLE ES.3

COST UTILIZATION INDEX

CUI = TOTAL ENERGY COST in $/YR/ CONDITIONED GROSS AREA in SQ. FT.

= $222,597 $/YR / 109,500 SQ. FT.

= $2.033 $/(SQ. FT.*YR)

TABLE ES.4

ENERGY CONSERVATION OPPORTUNITIES AT FOX ARMY HOSPITAL

The following list represents the ECO's investigated in this study. The list was derived from the Scope of Work. These ECO's are investigated further in Section 4 of this report.

<u>Heating, ventilating, and air-conditioning</u> (HVAC)

1. Shut off air handling units whenever possible.
2. Reduce outside air intake when air must be heated or cooled before use.
3. Reduce volume of air circulated through air handling units.
4. Shut off or reduce speed of room fan coils.
5. Shut off or reduce stairwell heating.
6. Shut off unneeded circulating pumps.
7. Reduce humidification to minimum requirements.
8. Reduce condenser water temperature.
9. Cycle fans and pumps.
10. Reduce pumping flow.
11. Reset thermostats higher during cooling and lower during heating.
12. Repair and maintain steam lines and steam traps.
13. Use damper controls to shut off air to unoccupied areas.
14. Reset hot and cold deck temperatures based on areas with greatest need.
15. Raise chilled water temperature.
16. Shed HVAC loads during peak electrical use periods.
17. Use outside air for free cooling whenever possible.
18. Reduce reheating of cooled air.
19. Recover heating or cooling with energy recovery units.
20. Reduce chilled water circulated during light cooling loads.
21. Install minimum sized motors to meet loads.
22. Replace hand valves with automatic controls.
23. Install variable air volume controls.
24. Insulate ducts and piping.
25. Eliminate simultaneous heating and cooling.
26. Install night setback controls.
27. Clean coils.
28. Maintain filters.
29. Repair and/or maintain air handling controls.
30. Multi speed/variable speed cooling tower fans.
31. Use centrifugal chillers instead of absorption chillers.

TABLE ES.4 continued

Boiler plant

1. Reduce steam distribution pressure.
2. Shut off steam to laundry when not in use.
3. Increase boiler efficiency.
4. Repair, replace, or install condensate return system.
5. Insulate boiler and boiler piping.
6. Install economizer.
7. Install air preheat.
8. Check boiler water chemistry program.
9. Clean boiler tubes.
10. Blowdown controls.
11. Boiler and chiller control modifications.
12. Common manifolding of chillers.
13. Water treatment to prevent tube fouling.

Lighting

1. Shut off lights when not needed.
2. Reduce lighting levels.
3. Revise cleaning schedules.
4. Convert to energy efficient systems.
5. Motion switch shutoff: Motion detection switch off: Delay shutoff.

Building envelope

1. Reduce infiltration by caulking and weatherstripping.
2. Install storm windows or double pane windows.
3. Install roof insulation.
4. Install loading dock seals.
5. Install vestibules on entrances.
6. Reduce window heat gain by solar shading, screening, curtains or blinds.
7. Install wall insulation.

TABLE ES.4 continued

Electrical equipment

1. Shut off elevators whenever possible.
2. Shut off pneumatic tube system whenever possible.
3. Install capacitors or synchronous motors to increase power factor.
4. Use emergency generator to reduce peak demand.
5. Shed or cycle electrical loads to reduce peak demand.
6. Balance loads.
7. Reduce transformer losses by proper loading and balancing.
8. Convert to energy efficient motors.

Plumbing

1. Reduce domestic hot water temperature.
2. Repair and maintain hot water and steam piping insulation.
3. Install flow restrictors.
4. Install faucets which automatically shut off water flow.
5. Decentralize hot water heating.
6. Add pipe insulation.

Laundry

1. Install head reclamation system for laundry wash water.
2. Install heat reclamation system on dryers.
3. Install heat reclamation system on irons.
4. Install thermal fluid heated equipment.

Kitchen

1. Shut off range hood exhaust whenever possible.
2. Install high-efficiency steam control valves.
3. Shut off equipment and appliances whenever possible.
4. Install makeup air supply for exhaust.
5. Install heat reclamation system for exhaust heat.
6. Turn off lights in coolers.

Miscellaneous

1. Install incinerator and heat recovery system.
2. Install computerized energy monitoring and control system.

TABLE ES.5

ECO's INCLUDED IN PROJECTS

PROJECT: Redstone Arsenal, Huntsville, Alabama
BUILDING: #4100, Fox Army Hospital

ECO Description	SAVINGS KWH	MBTU	GAL - #5	MBTU	$	MBTU	Simple Payback YRS.	SIR	APPENDIX C ECO PAGE NUMBER
Boiler Tune-up - Operation & Maintenace			20054	2948	$13,637	2948	0.40	36.24	332
Lavatory Flow Regulator Analysis			789	116	$536	116	1.30	19.01	341
Energy Saving Showerhead Analysis			1054	155	$685	155	1.36	13.92	346
Light Reduction Analysis	95555	1108			$4,119	1108	0.99	13.52	288
Fluorescent Conversion Analysis - 5096 hr	16990	197			$733	197	2.90	5.91	230
Silver Optical Light Reflector Instal. - 8760 hrs.	39498	458			$1,703	458	2.31	5.88	274
Oxygen Trim System			11238	1652	$7,643	1652	4.30	4.23	307
Optimizing Air Distribution System - AHU #5	85000	986			$3,666	986	2.14	4.20	6
Energy Efficient Motor Replacement - M. # 1	9606	111			$414	111	3.19	3.54	132
Energy Efficient Motor Replacement - M. # 24	5760	67			$248	67	3.54	3.21	132
Energy Efficient Motor Replacement - M. # 18	7040	82			$304	82	3.64	3.13	132
Fluorescent Conversion Analysis - 2600 hr	2329	27			$101	27	5.70	3.12	224
Energy Efficient Motor Replacement - M. # 26	6749	78			$291	78	3.79	2.98	132
Energy Efficient Motor Replacement - M. # 23	4491	52			$194	52	3.87	2.93	132
Energy Efficient Motor Replacement - M. # 2	6594	76			$284	76	3.88	2.90	132
Heat Pump Water Heater	-29581	-343	3014	443	$794	100	10.50	2.83	94
Dishwater Waste Heat Recovery	-657	-8	1501	221	$992	213	7.00	2.73	367
Energy Efficient Motor Replacement - M. # 21	4889	57			$211	57	4.17	2.73	132
Energy Efficient Motor Replacement - M. # 3	2260	26			$97	26	4.27	2.63	132
Energy Efficient Fluorescent Lamp Retrofit - 8760 hr.	37256	432			$1,606	432	3.50	2.59	259
Energy Efficient Motor Replacement - M. # 4	2104	24			$89	24	4.58	2.43	132
Energy Efficient Motor Replacement - M. # 35	4225	49			$182	49	4.83	2.35	132
Energy Efficient Motor Replacement - M. # 10	6284	73			$271	73	4.88	2.33	132
Supply Make-up Air to Kitchen Exhaust Hood	-9262	-108	1177	173	$401	65	7.40	2.17	352
Optimizing Air Distribution System - AHU #1	33275	386			$1,435	386	4.40	2.05	2
Energy Efficient Motor Replacement - M. # 40	5355	62			$231	62	5.72	1.98	132
Energy Efficient Motor Replacement - M. # 41	5240	61			$227	61	5.85	1.94	132
Energy Efficient Motor Replacement - M. # 12	4291	50			$186	50	5.97	1.91	132
Optimizing Air Distribution System - AHU #6	22931	266			$989	266	4.83	1.86	11
Feedwater Economizer			3701	544	$2,515	544	9.60	1.85	321
Energy Efficient Motor Replacement - M. # 31	3189	37			$138	37	6.40	1.77	132
Reciprocating Chiller Installation	-113793	-1320	20000	2940	$10,559	1620	6.87	1.76	112
Energy Efficient Motor Replacement - M. # 27	1576	18			$68	18	6.74	1.66	132
Energy Efficient Motor Replacement - M. # 37	1998	23			$86	23	7.31	1.54	132
Energy Efficient Motor Replacement - M. # 34	2783	32			$120	32	7.33	1.53	132
Energy Efficient Motor Replacement - M. # 11	1172	14			$51	14	8.23	1.42	132
Damper Control Shut-off and Motor Control #2	24538	284	1293	190	$1,937	474	7.68	1.38	48
Centrifugal Chiller Installation	-100000	-1160	20000	2940	$10,927	1780	10.10	1.20	104
Energy Efficient Motor Replacement - M. # 7	3077	36			$133	36	9.96	1.15	132
Energy Efficient Motor Replacement - M. # 32	1928	22			$83	22	10.58	1.05	132
Energy Efficient Motor Replacement - M. # 6	1912	22			$82	22	10.67	1.05	132
Energy Efficient Motor Replacement - M. # 19	667	8			$29	8	11.60	1.01	132

TABLE ES.6

PROJECT DESCRIPTION BY ECO

PROJECT NAME. ECO Description	MBTU	------------- TOTALS ------------- $ SAVINGS	$ COST :	SIMPLE PAYBACK YRS.	SIR :
1. BOILER OPTIMIZATION.	5144	$23,795	$62,440	2.62	5.78
Boiler Tune-up - Operation & Maintenace					
Oxygen Trim System					
Feedwater Economizer					
2. SUPPLY MAKE-UP AIR TO KITCHEN EXHAUST HOOD PROJECT.	65	$401	$2,951	7.40	2.17
Supply Make-up Air to Kitchen Exhaust Hood					
3. TEST AND BALANCE PROJECT.	1638	$6,090	$51,307 *	8.42	1.07
Optimizing Air Distribution System - AHU #5					
Optimizing Air Distribution System - AHU #1					
Optimizing Air Distribution System - AHU #6					
* COSTS INCLUDE COMPLETE AIR AND WATER SIDE BALANCE OF AHU's					
4. ENERGY EFFICIENT MOTOR PROJECT.	1080	$4,019	$20,606	5.13	2.21
Energy Efficient Motor Replacement - M. # 1					
Energy Efficient Motor Replacement - M. # 24					
Energy Efficient Motor Replacement - M. # 18					
Energy Efficient Motor Replacement - M. # 26					
Energy Efficient Motor Replacement - M. # 23					
Energy Efficient Motor Replacement - M. # 2					
Energy Efficient Motor Replacement - M. # 21					
Energy Efficient Motor Replacement - M. # 3					
Energy Efficient Motor Replacement - M. # 4					
Energy Efficient Motor Replacement - M. # 35					
Energy Efficient Motor Replacement - M. # 10					
Energy Efficient Motor Replacement - M. # 40					
Energy Efficient Motor Replacement - M. # 41					
Energy Efficient Motor Replacement - M. # 12					
Energy Efficient Motor Replacement - M. # 31					
Energy Efficient Motor Replacement - M. # 27					
Energy Efficient Motor Replacement - M. # 37					
Energy Efficient Motor Replacement - M. # 34					
Energy Efficient Motor Replacement - M. # 11					
Energy Efficient Motor Replacement - M. # 7					
Energy Efficient Motor Replacement - M. # 6					
Energy Efficient Motor Replacement - M. # 32					
Energy Efficient Motor Replacement - M. # 19					

TABLE ES.6

PROJECT DESCRIPTION BY ECO

PROJECT NAME. ECO Description	TOTALS MBTU	TOTALS $ SAVINGS	TOTALS $ COST	SIMPLE PAYBACK YRS.	SIR
5. LIGHTING PROJECT.	3354	$12,474	$51,010	4.09	2.67
Light Reduction Analysis					
Fluorescent Conversion Analysis - 5096 hr					
Energy Efficient Fluorescent Lamp Retrofit - 8760 hr.					
Silver Optical Light Reflector Instal. - 8760 hrs.					
Fluorescent Conversion Analysis - 2600 hr					
6. DOMESTIC HOT WATER ENERGY REDUCTION PROJECT.	584	$3,020	$17,084	5.66	3.91
Lavatory Flow Regulator Analysis					
Energy Saving Showerhead Analysis					
Heat Pump Water Heater					
Dishwater Waste Heat Recovery					
7. UNOCCUPIED ZONE SHUTDOWN PROJECT.	1147	$4,709	$45,371	9.63	1.11
Damper Control Shut-off and Motor Control #2					
Damper Control Shut-off and Motor Control #9					
Damper Control Shut-off and Motor Control #5					
1. OPERATION AND MAINTENANCE RECOMMENDATION.	1780	$10,297	$110,346	10.10	1.20
Centrifugal Chiller Installation					
TOTALS:	14792	$64,805	$361,115	5.57	

Note: The energy savings total above includes synergistic effects between ECO's.

TABLE ES-7

ECOs NOT APPLICABLE OR ALREADY IMPLEMENTED AT FOX ARMY HOSPITAL

SYSTEM	NO.	ECO
HVAC	1	Shut off air handling units whenever possible. Already done. All air handling units that are running continuously serve 24 hour/day areas. Partial zone shut off is addressed elsewhere.
HVAC	4	Shut off or reduce speed of room fan coils. There are no fan coils in the hospital.
HVAC	5	Shut off or reduce stairwell heating. Already done.
HVAC	6	Shut off unneeded circulating pumps. The feedwater pumps are running only when the boiler or chiller requires them, otherwise, the pumps are cycled off. Circulating pumps cannot be turned off because all circulating systems (domestic hot water, hot water for space heating, and chilled water) serve 24 hour/day areas.
HVAC	7	Reduce humidification to minimum requirements. Humidification is already at minimum Army hospital specifications. Not applicable to hospital.
HVAC	8	Currently the cooling towers are providing the lowest temperature condenser water ambient wet bulb temperatures will allow. Water treatment appears to be controlling scale and algae growth, therefore this ECO is already done.
HVAC	12	Repair and maintain steam lines and steam traps. The steam lines and traps are in good conditions. Repair and maintenance of these lines are recommended as an O&M measure.

TABLE ES-7 continued

HVAC	14	Reset hot and cold deck temperatures based on areas with greatest need. Currently zone thermostats served by a particular air handling unit (AHU) resets the AHU's dicharge air temperature based on the zone requiring the greatest amount of reheat. Already done.
HVAC	15	This strategy is not appropriate for the hospital. The hospital cooling plant is designed to produce constant temperature chilled water. Two way valves at the AHU meters the chilled water flow to a minimum, to meet the AHU's discharge requirements.
HVAC	16	The emergency generator is used to reduce peak demand during peak cooling periods. Already done.
HVAC	17	Use outside air for free cooling whenever possible. Fox Army Hospital already employs enthalpy economizers on all air handling units. The economizers are working properly with a manual shutoff of chiller when outside air falls below 55 F.
HVAC	23	This ECO can not be accomplished because the air flows currently in use or recommended are at minimum values. When zones are unoccupied, shutdown is recommended (see ECO pg 48 - 60). Some AHU's are currently shutdown. Air flow can not be reduced below current levels therefore VAV is not appropriate for the hospital.
HVAC	24	Insulate ducts and piping. Already done.
HVAC	25	Eliminate simultaneous heating and cooling. Already done. The baseboard heaters do not operate during any cooling.
HVAC	26	Install night setback controls. Not applicable. Air handling units are either shut off or must serve 24 hour zones. Space temperatures

TABLE ES-7 continued

		in occupied areas are regulated by ETL 1110-3-344.
HVAC	27	Clean coils. Recommended as an O&M measure.
HVAC	28	Maintain filters. Recommended as an O&M measure.
HVAC	29	Repair and/or maintain air handling controls. These were judged to be in good shape, in general, from the field survey.
HVAC	30	This strategy is not appropriate for the hospital. Operation of the cooling towers is based on which of the chillers is operating and the leaving water temperature from the cooling tower. From cut sheets describing the centrifugal chillers performance requirements states that the evaporator leaving temperature is 43 F. From York literature the minimum condenser supply temperature should approach 62-63F. Ambient wetbulb temperature is the limiting condition for achieving a given condenser water temperature. Therefore, the cooling tower fan should operate until the ambient wetbulb reaches approximately 62 Fwb. This is approximately the same outside air (OA) conditions at which the outside air economizer is invoked.
Boiler	1	Reduce steam distribution pressure. The steam pressure is presently at 90 psig. The steam pressure cannot be reduced further because of the many high-pressure demands throughout the hospital.
Boiler	2	Shut off steam to laundry when not in use. No laundry in hospital.
Boiler	4	Repair, replace, or install condensate return system. The condensate return system is already installed and is in good shape.
Boiler	5	Insulate boiler and boiler piping. Both the boiler and its piping are well insulated, and the insulation is in good condition.

TABLE ES-7 continued

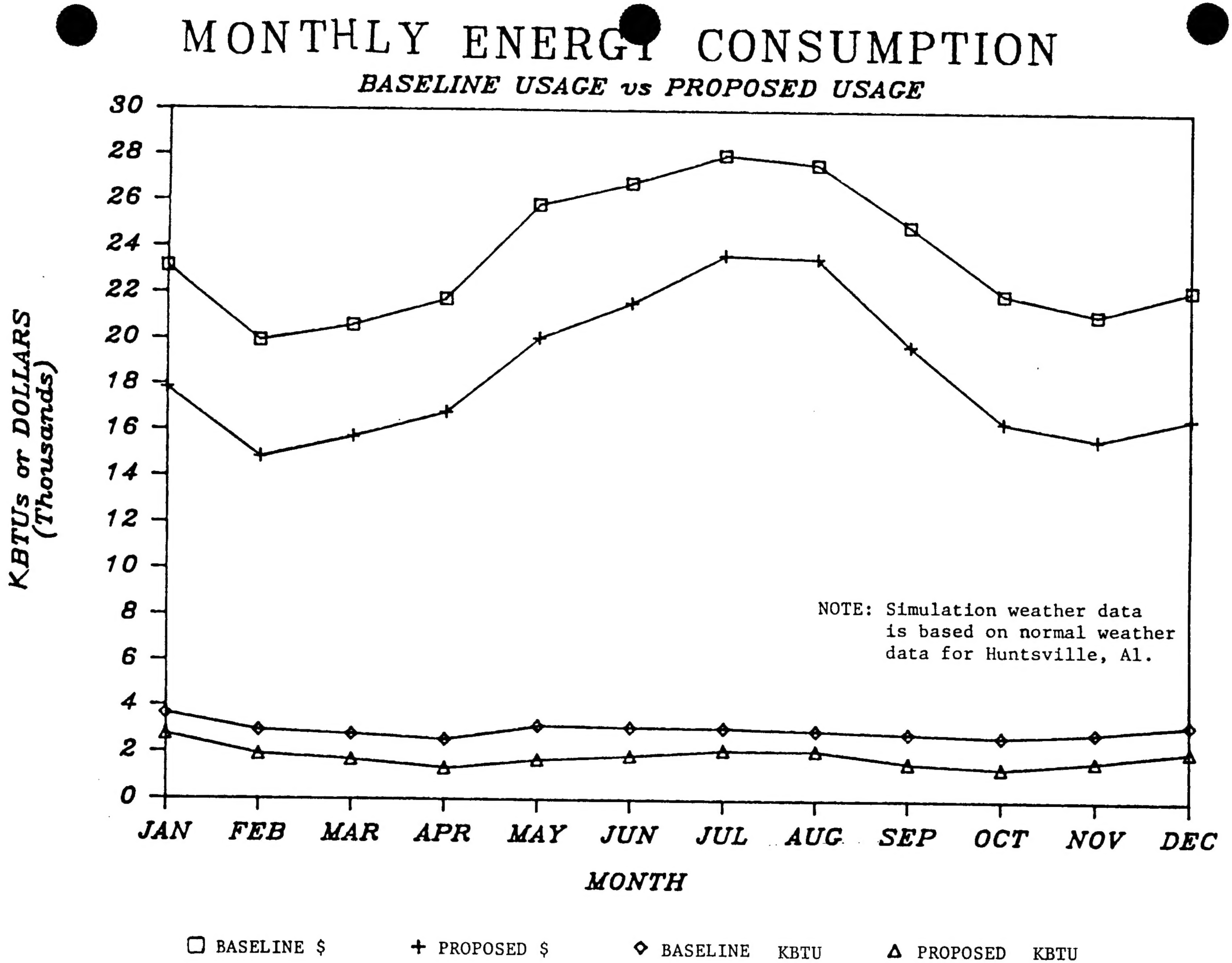
Boiler	8	Check boiler water chemistry program. Program samples and analyzes water once a day and was observed to be within major quality parameters.
Boiler	9	Clean boiler tubes. Already done.
Boiler	10	Blowdown controls. Manual blowdown is performed daily (minimum) or each shift (maximum) depending on the chemical test readings. Blowdown lasts 5 seconds. There is no present need for automatic controls or for continuous blowdown on small boilers (under 10,000 lbs/hr). A conductivity monitoring system is examined.
Boiler	12	Common manifolding of chillers. Chillers are common manifolded now.
Boier	13	Water treatment to prevent tube fouling Water samples are analyzed on a daily basis and are well within water quality parameters
Lighting	1	Shut off lights when not needed. Recommended as an O&M measure.
Lighting	3	Revise cleaning schedules. No changes necessary.
Lighting	5	Motion switch shutoff: Motion detection switch off: Delay shutoff. Field surveys of the hospital (during the day and at night) revealed that lights are turned off by occupants when leaving their work stations.
Envelope	1	Reduce infiltration by caulking and weatherstripping. Already done.
Envelope	2	Install storm windows or double pane windows. Excluded at the kickoff meeting.
Envelope	3	Install roof insulation. Already there. R = 20.
Envelope	4	Install loading dock seals. Already have an air curtain.

TABLE ES-7 continued

Envelope	7	Install wall insulation. Already there. R = 6.7
Electrical	1	Shut off elevators whenever possible. Cannot shut off elevators by directive of Major Swinney, 8/7/87).
Electrical	2	Shut off pneumatic tube system whenever possible. No pneumatic tubes in hospital.
Electrical	4	Use emergency generator to reduce peak demand. Already done.
Electrical	6	Balance loads. From the initial design, the loads were properly balanced at the source. There have been no additions to the design. Therefore, the loads are still balanced.
Electrical	7	Reduce transformer losses by proper loading and balancing. From the initial design, the loads were properly balanced at the source. There have been no additions to the design. Therefore, the loads are still balanced.
Plumbing	1	Reduce domestic hot water temperature. Hot water temperature presently at acceptable 120F.
Plumbing	2	Repair and maintain hot water and steam piping insulation. Recommended as an O&M measure.
Plumbing	4	Install faucets which automatically shut off water flow. Not cost-effective. Aerators are recommended instead.
Plumbing	5	Decentralize hot water heating. Hot water heating is used continuously throughout the hospital and cannot be decentralized.

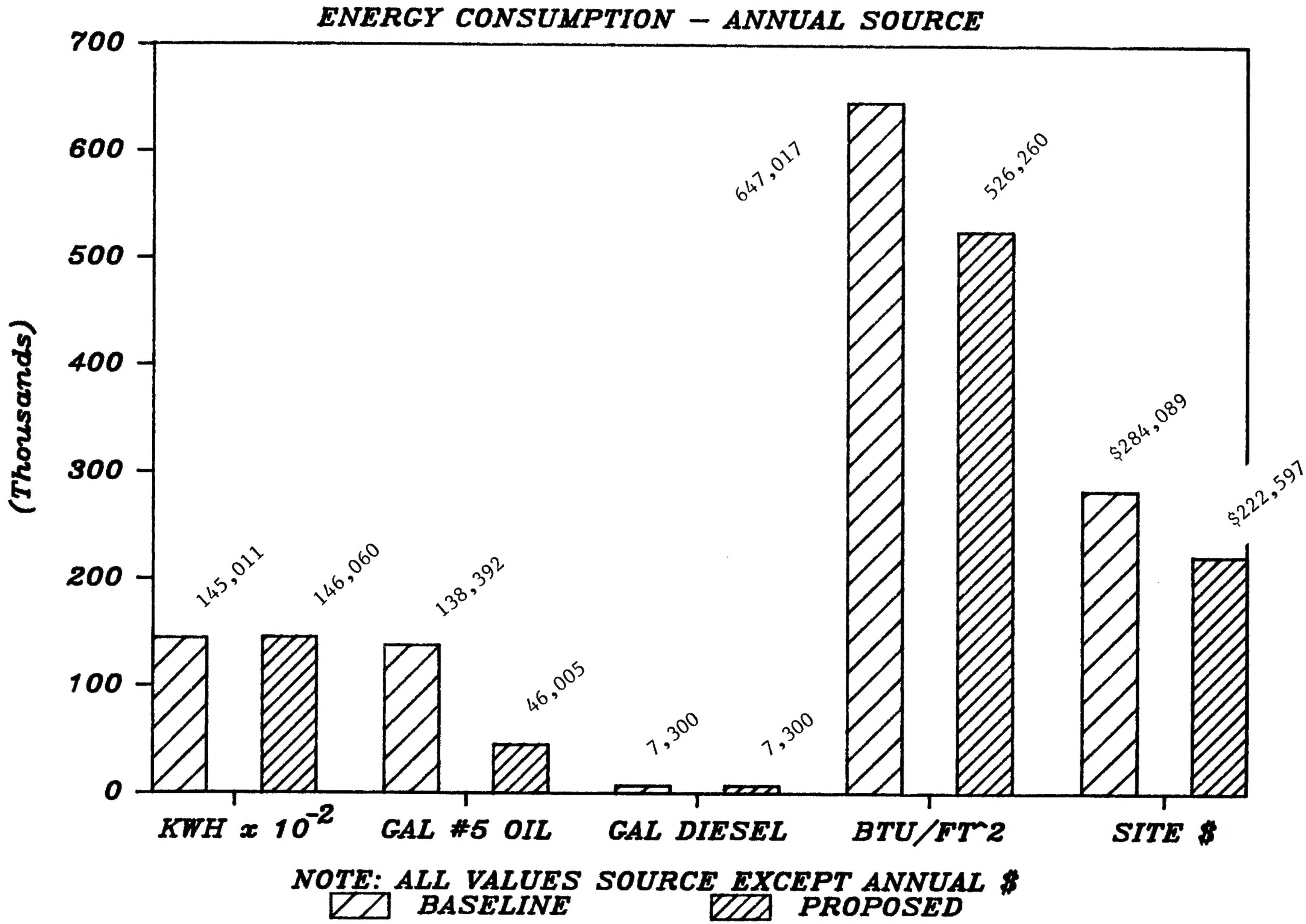
TABLE ES-7 continued

Plumbing	6	Add pipe insulation. Already done.
Laundry	1	Install heat reclamation system for laundry wash water. No laundry on premise.
Laundry	2	Install heat reclamation system on dryers. No laundry on premise.
Laundry	3	Install heat reclamation system on irons. No laundry on premise.
Laundry	4	Install thermal fluid heated equipment. No laundry on premise.
Kitchen	1	Shut off range hood exhaust whenever possible. Recommended as an O&M.
Kitchen	2	Install high efficiency steam control valves. Inefficiency in steam distribution lines is created by pressure drops. Therefore, pressure reducing valves are inherently inefficient.
Kitchen	3	Shut off equipment and appliances whenever possible. Already done.
Kitchen	6	Turn off lights in coolers. Already done.
Misc.	1	Install incinerator and heat recovery system. Energy-recovery incinerators are no longer allowed (Huntsville Division C.O.E. - Jan. 21, 1987 Review Meeting) and the present unit is inoperable.



GRAPH ES.1 - ANNUAL ENERGY CONSUMPTION ON A MONTH BY MONTH BASIS

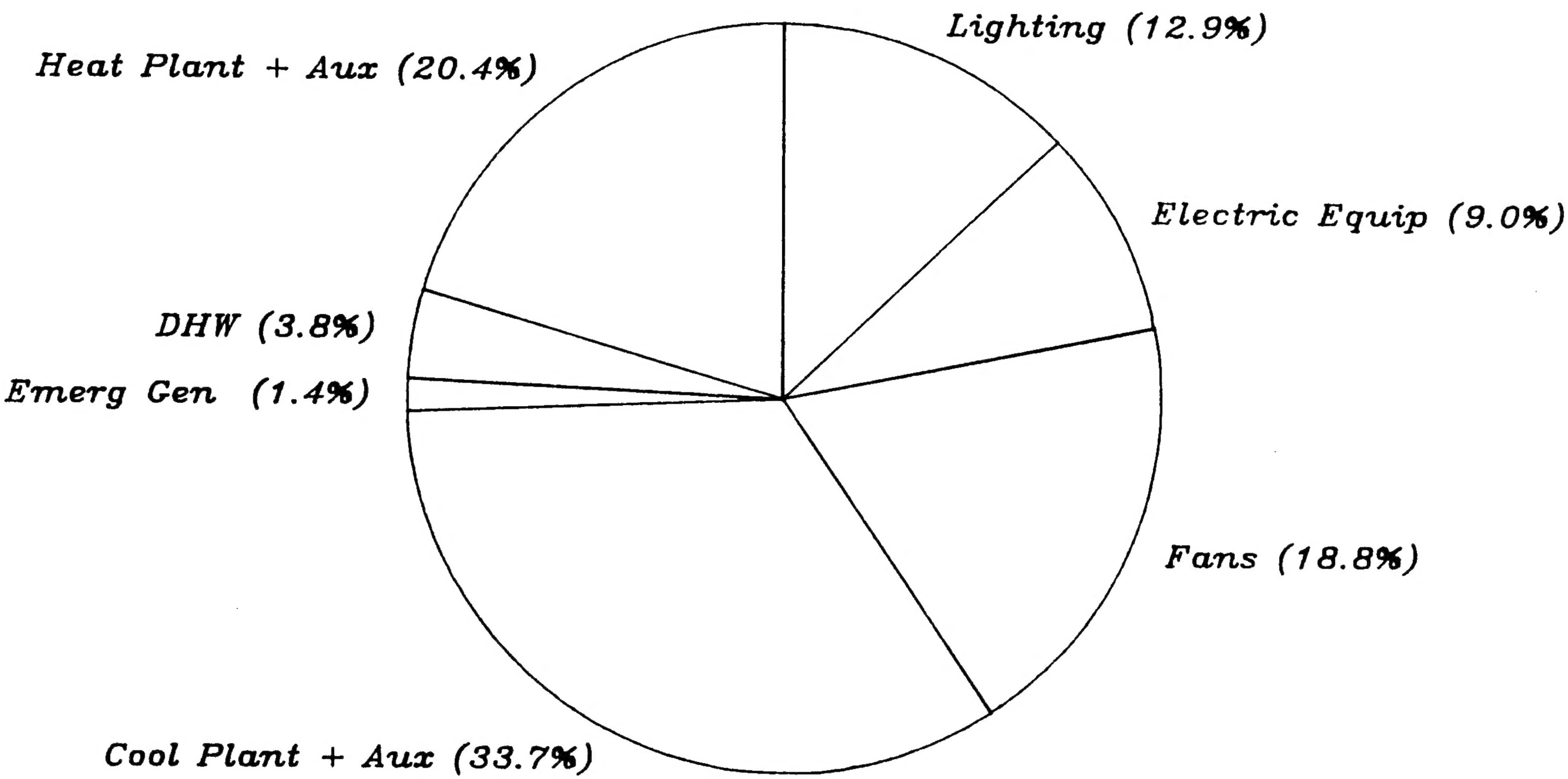
BASELINE VS PROPOSED ENERGY USAGE



GRAPH ES-2

BASELINE ENERGY CONSUMPTION – SOURCE

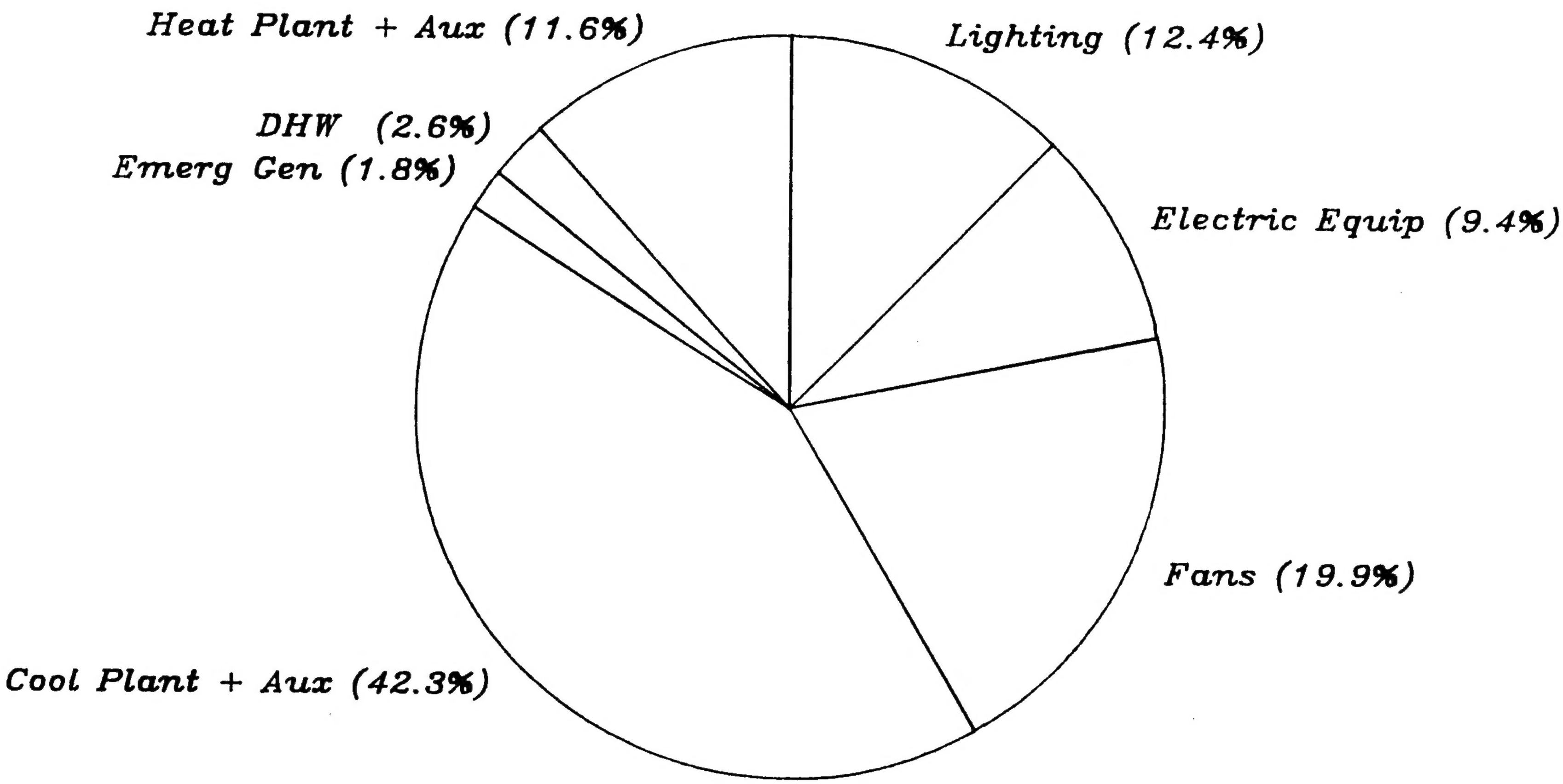
– ANNUAL BTU / FT^2 –



GRAPH ES.3 - BASELINE ENERGY CONSUMPTION BY END USE
(BTU/SQ.FT.)

PROPOSED ENERGY CONSUMPTION – SOURCE

– ANNUAL BTU / FT^2 –



GRAPH ES.4 - PROPOSED ENERGY CONSUMPTION BY END USE
(BTU/SQ.FT.)